

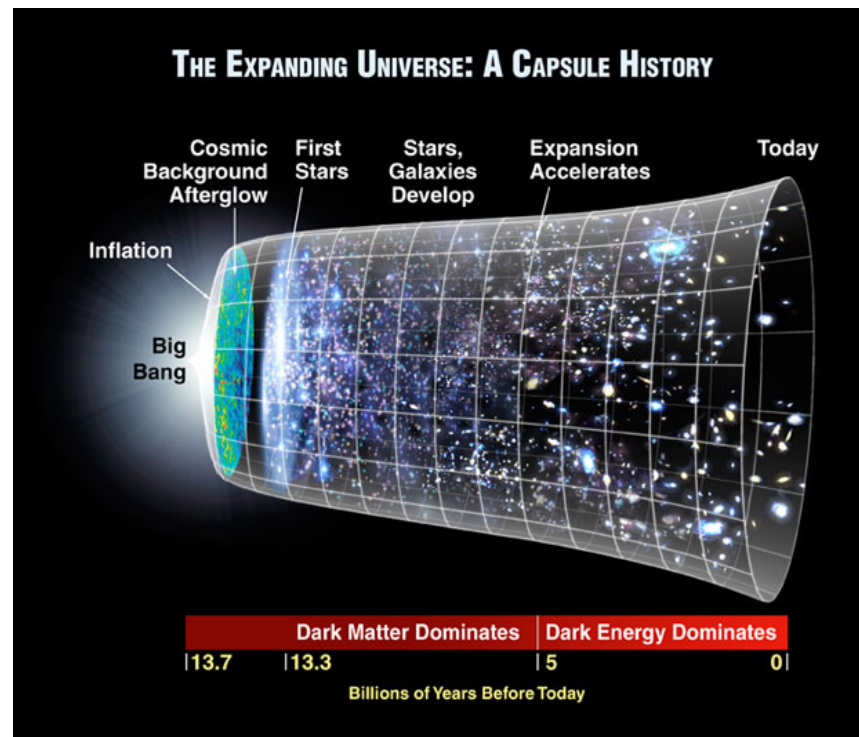


PreCam Survey Image Analysis

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What is Dark Energy?

- In 1998, astronomers discovered that the expansion rate of the universe is accelerating
- Dark energy causes this acceleration
- Accounts for 73% of the total energy density of the universe
- Nature unknown



Dark Energy Survey (DES)

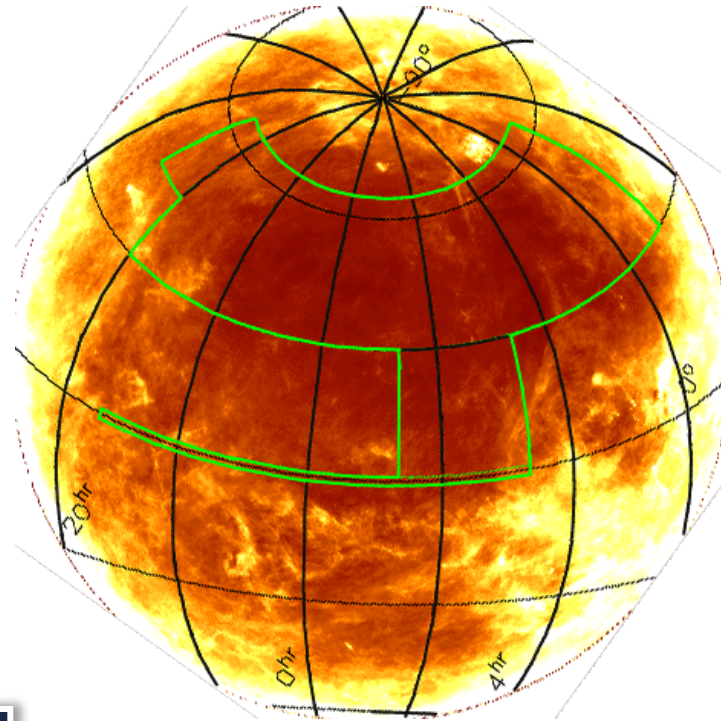
- International collaboration of ~100 scientists from ~20 institutions
- Probe nature of dark energy by testing evolution of:
 1. the clustering of dark matter (via weak lensing)
 2. the clustering of galaxies
 3. the distribution of galaxies
 4. the magnitude at peak brightness of Type Ia supernovae



THE DARK ENERGY SURVEY

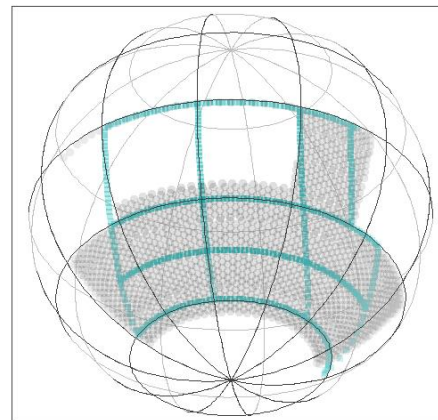
Dark Energy Survey (DES)

- 5000 sq deg *grizy* imaging survey of Southern Galactic Cap (5 yrs) starting this winter
- Conducted on CTIO Blanco 4m telescope (Chile)
- Will use new wide-field camera (DECam)



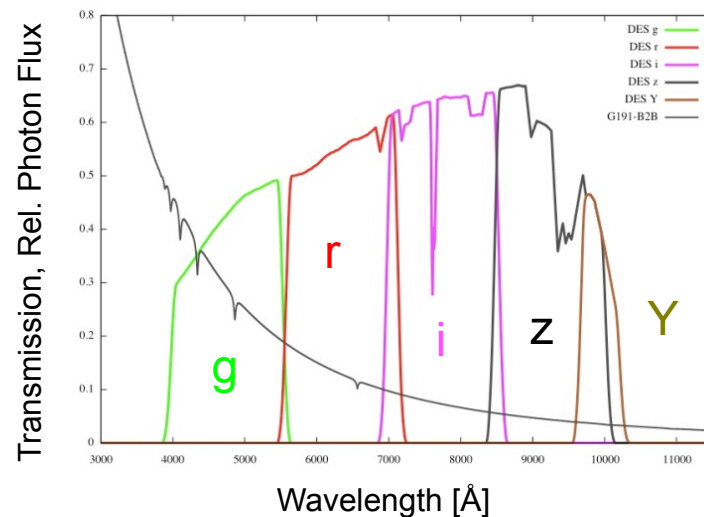
PreCam Survey

- Objective: Create a network of calibrated DES *grizy* standard stars (photometric calibration)
- Photometry – Measurement of the intensity of light (magnitude)
- Within DES footprint
- Used small camera on UM Curtis-Schmidt telescope (0.61 m) at CTIO



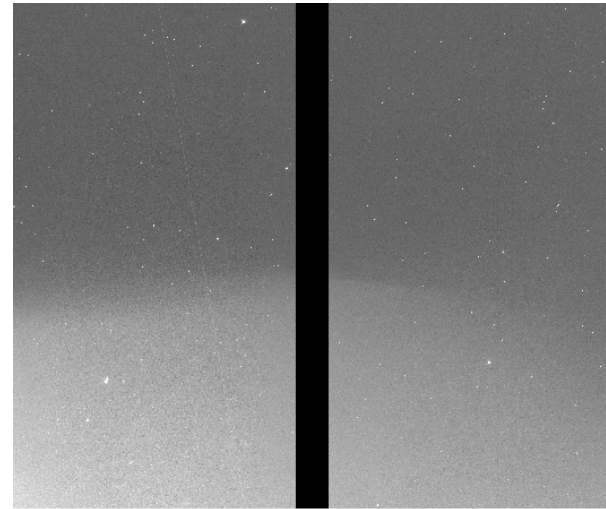
PreCam: My Research

- My objectives: research methods for astrometry (measurement of position of stars) and photometric calibrations
- Benefits:
 - Permits better nightly photometry during DES operations
 - Improved relative calibrations for DES
 - y-band standard stars (very few red standard stars exist)



PreCam Images

- Focused on 'golden nights'
- Use ds9 to view images and catalog overlays
- Each image was taken with 2 CCDs



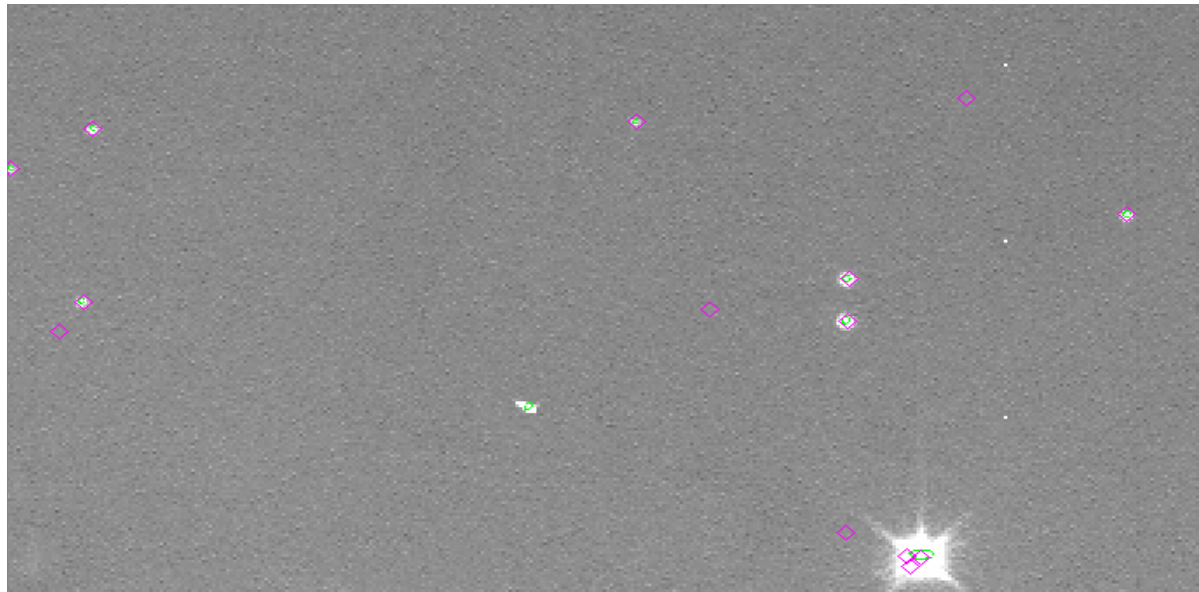
Programming in Python

- Wrote my own programs (~20) to perform astrometry and photometry
- When comparing catalogs, must determine 'matched' objects
- Used in all aspects of analysis



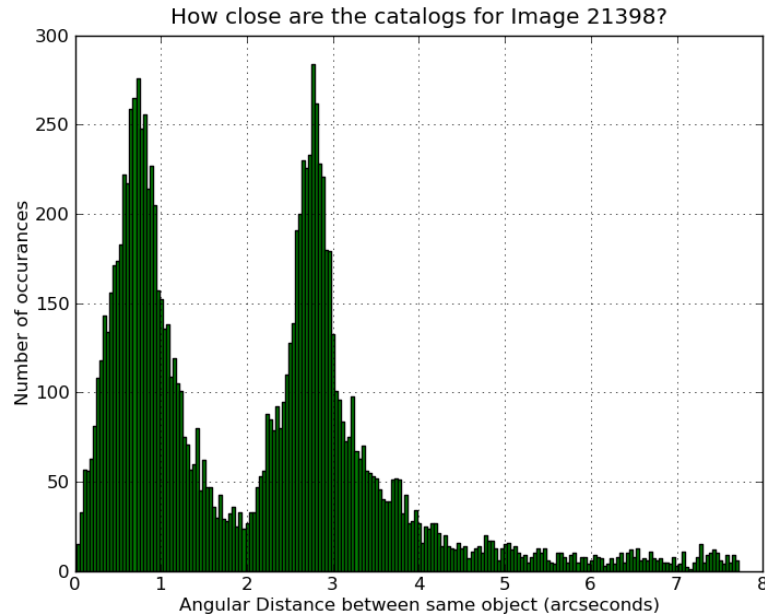
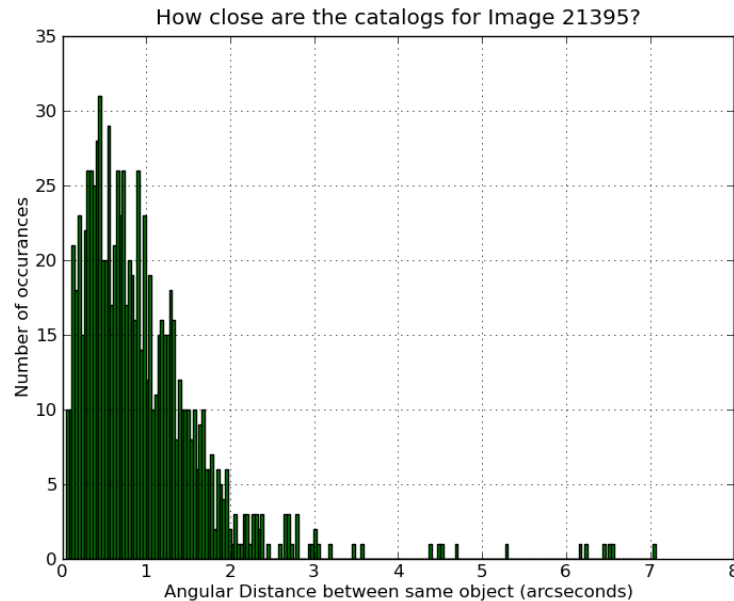
python

PreCam Astrometry



- Created reference catalogs in ds9 from the GSC 2.2 online catalog
- Ran Source Extractor (SExtractor) to create object catalogs
- Produced region file overlaying SExtractor catalog

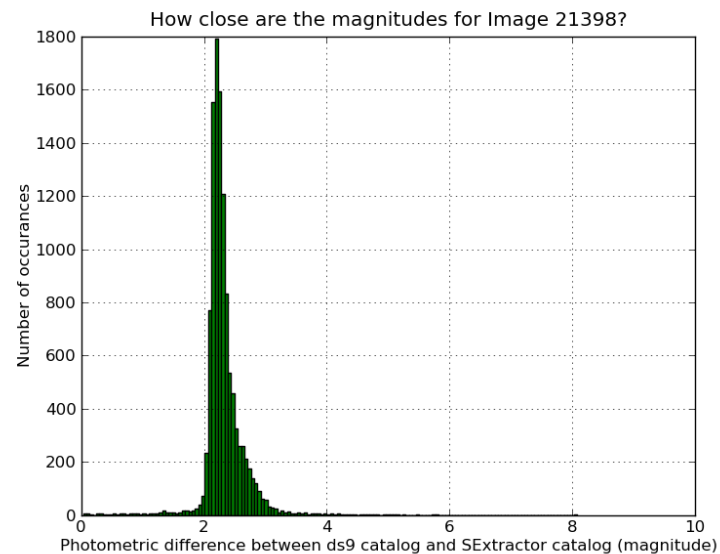
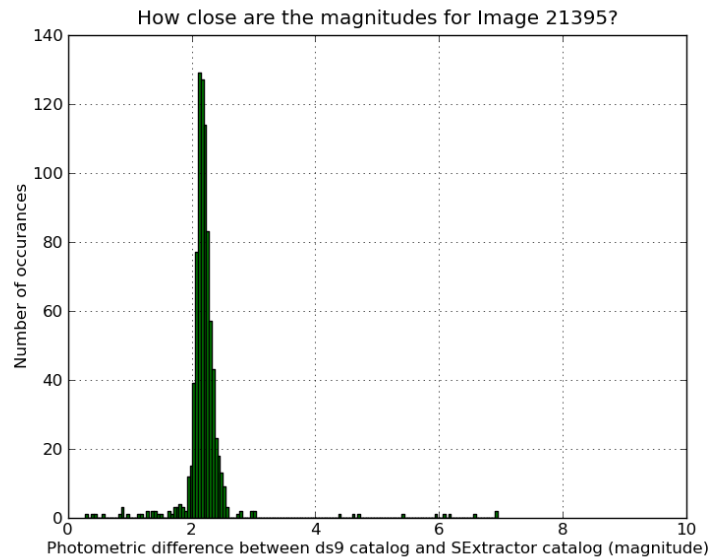
Astrometry Results



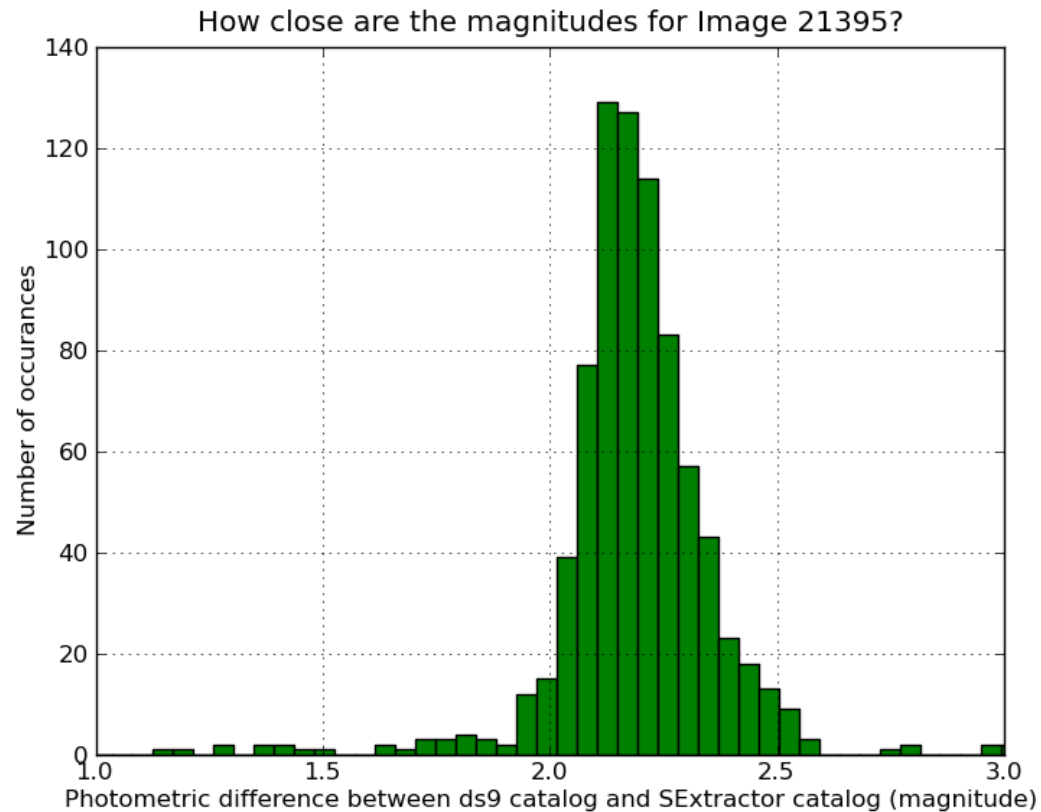
- Looking for narrow peaks indicating correct object matching
- Double peaks caused by 2 CCDs
 - Confirmed by splitting image

PreCam Photometry

- Calibration of photometry in PreCam images
- Used GSC 2.2 as reference catalog
- Wrote program that compares measured magnitudes of 'matched' stars

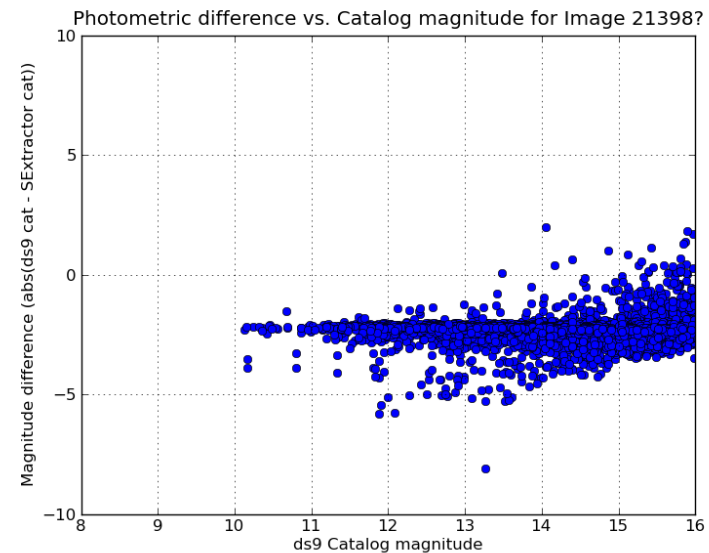
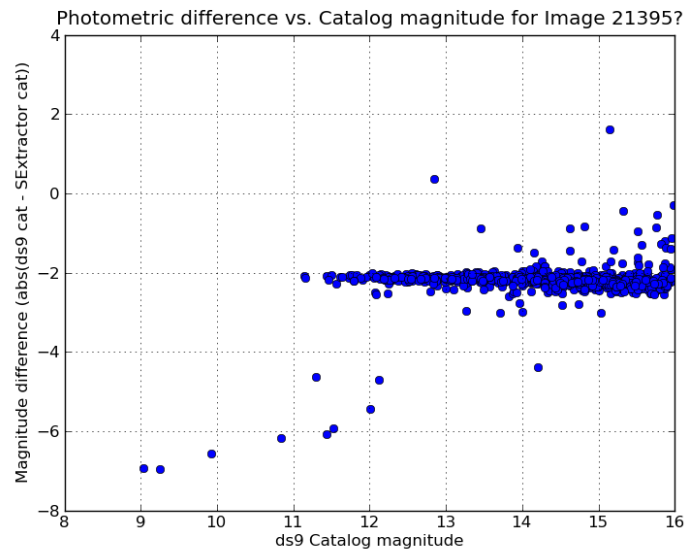


Photometry: Accuracy



- Sigma and accuracy
 - Sigma~0.1
- $\Delta m * 100 \sim$ %intensity change
- Intensity accuracy=10%

Photometry Results



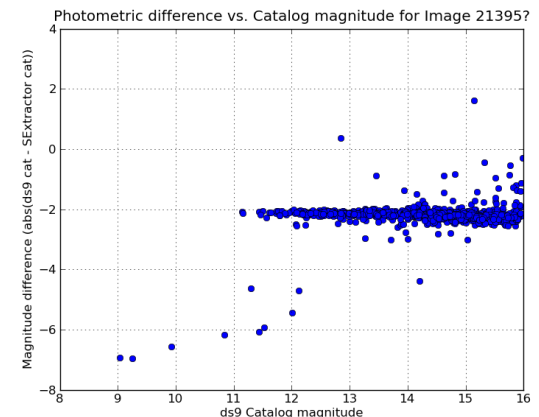
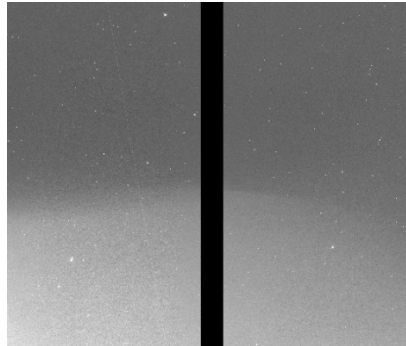
- Scatter plots (Δm vs m) reveal distribution
- Want narrow peaks
- Observe outliers

Photometry Analysis

- Do outliers have a common cause?
- Edges of CCD could be an issue
- Use a border of about 7% total size

```
# Filename: /home/des/data/golden/R20110112UT/r/ccmap-wcs-tttpreca
# Region file format: DS9 version 4.1
# Filename: /home/des/data/golden/R20110112UT/r/ccmap-wcs-tttpreca
global color=green dashlist=8 3 width=1 font="helvetica 10 normal
physical
ellipse(4190.794000,3939.258000,1.688000,0.958000,44.790000)
ellipse(4176.729000,3897.800000,1.092000,0.688000,77.530000)
ellipse(4194.968000,2847.370000,1.027000,0.723000,16.790000)
ellipse(4150.198000,3825.988000,0.805000,0.502000,-60.440000)
ellipse(4209.977000,416.297000,1.260000,0.997000,-89.330000)
ellipse(4116.580000,1458.099000,1.700000,0.994000,41.820000)
ellipse(4073.498000,1747.977000,1.247000,0.951000,20.590000)
ellipse(3933.190000,2633.780000,0.748000,0.562000,42.340000)
ellipse(3888.433000,2809.909000,1.288000,1.007000,59.530000)
ellipse(3834.300000,1747.986000,0.730000,0.652000,3.440000)
ellipse(3736.613000,3387.143000,0.758000,0.442000,17.540000)
ellipse(3674.511000,2811.884000,0.766000,0.500000,-0.550000)
ellipse(3522.081000,24.073000,1.207000,0.965000,33.600000)
ellipse(3414.417000,2313.226000,0.716000,0.459000,-21.010000)
ellipse(3425.394000,1718.183000,0.708000,0.456000,-20.650000)
ellipse(3341.457000,2717.035000,1.261000,0.935000,21.940000)
ellipse(3299.973000,1396.342000,0.724000,0.649000,83.130000)
ellipse(3101.392000,3092.971000,1.719000,0.828000,69.500000)
ellipse(3053.136000,2933.656000,0.854000,0.682000,-24.820000)
ellipse(3111.829000,812.368000,1.101000,0.979000,72.330000)
ellipse(2962.809000,3609.646000,0.862000,0.668000,20.530000)
ellipse(2925.737000,3960.148000,1.157000,0.967000,27.610000)
ellipse(2951.152000,2018.613000,0.728000,0.450000,69.260000)
ellipse(2915.700000,1785.900000,0.711000,0.659000,-21.620000)
ellipse(2817.536000,3822.999000,0.762000,0.498000,-0.960000)
ellipse(2930.312000,870.533000,0.980000,0.956000,-9.830000)
ellipse(2895.202000,1083.614000,0.712000,0.458000,70.520000)
ellipse(2857.205000,1850.403000,0.732000,0.450000,-72.150000)
ellipse(2862.033000,1683.404000,1.085000,0.984000,12.350000)
```

- About 44% are edge objects for $\Delta m < -2.4$
- About 74% for $\Delta m > -1.9$





Acknowledgments

- ◉ My adviser: Michael Schubnell
- ◉ Other members of the research team: Greg Tarlé, Tomasz Biesiadzinski
- ◉ From Fermi Lab: Sahar and Douglas Tucker
- ◉ University of Michigan Department of Physics and Jim Liu

References

<http://www.darkenergysurvey.org/>

<http://des-docdb.fnal.gov/0040/004047/005/PreCamObservingProposal.pdf>

<http://www.idgresearch.com/>

<http://spiff.rit.edu/classes/phys440/lectures/mag/mag.html>

PowerPoints by Douglas Tucker



Thank You for
Listening!